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Minerals Environmental In-House and Contract Research and Development in Fiscal Year 1981

By Staff, Division of Minerals Environmental Technology

UNITED STATES DEPARTMENT OF THE INTERIOR

United States Bureau of Mines

Information Circular 8844

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UNITED STATES DEPARTMENT OF THE INTERIOR
James G. Watt, Secretary
BUREAU OF MINES

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CONTENTS

	Page
Abstract	1
Introduction	2
Program outline	2
Mine waste control	3
Water management	3
In-house projects	4
Contract projects	6
Solid waste management	10
In-house projects	10
Contract projects	13
Process waste control	18
Effluents and emissions control	18
In-house projects	18
Contract projects	20
Accessory minerals control	21
In-house projects	22
Contract projects	24
Mined-land reclamation	24
Land restoration	25
In-house projects	25
Contract projects	28
Surface stability	36
In-house projects	36
Contract projects	38
Special environmental problems	40
Noise and vibration control	41
In-house projects	41
Contract projects	42
Environmental systems analysis	43
In-house projects	43
Contract projects	45
Particulate emissions control	47
In-house projects	47
Contract projects	48

MINERALS ENVIRONMENTAL IN-HOUSE AND CONTRACT RESEARCH AND DEVELOPMENT IN FISCAL YEAR 1981

by

Staff, Division of Minerals Environmental Technology

ABSTRACT

This publication summarizes the in-house and contract research and development projects programed for fiscal year 1981 by the Bureau of Mines under its Minerals Environmental Technology activity. The document provides a mechanism for interested parties, including potential contractors, to gain insight into ongoing and projected work of the Bureau's environmental research efforts.

Research to identify and correct environmental problems associated with mining and metallurgical operations has long been an integral part of the Bureau's mission. The environmental research and demonstration activities of the Bureau were consolidated in 1979 with the formation of the Minerals Environmental Technology program, which is directed toward the elimination or reduction of environmental problems associated with the extraction and processing of minerals. Among the efforts underway are development of data and technology for assessing the potential environmental impact of minerals development, for monitoring minerals extraction operations, and for establishing viable reclamation requirements on abandoned mine lands; development and demonstration of technology for control of environmental disturbances during minerals extraction operations; development and demonstration of land reclamation and mine closure techniques to restore or enhance the productive use of mined lands; development of engineering techniques that incorporate state-of-the-art mining environmental technology in the design and planning of minerals extraction operations; development and demonstration of new mining systems that greatly reduce or eliminate the adverse environmental impacts of minerals extraction; and providing the technologic base for Federal, State, and local establishment of enviromental standards for mining operations. Included in the minerals-processing-related work are projects to clean mineral-processing waters; demonstrate a Bureau process for scrubbing SO_2 from powerplant stack gas; recover dissolved minerals from process streams; stabilize discarded dusts, slags, and tailings; remove hazardous contaminates from byproduct wastes; reduce generation of waste solids; and improve metallurgical process engineering to eliminate pollution. Approximately $21 million was appropriated for this work in fiscal year 1981.

INTRODUCTION

This summary document is intended to provide a means for interested parties to obtain general information about the Bureau's environmental research and development programs, and also is meant to serve as a decision-making aid for R&D firms contemplating participation in the contract program.

Contracting in the Bureau of Mines is conducted in strict accordance with Federal Procurement Regulations, and solicitation is conducted by formal advertisement in the Commerce Business Daily. No additional information will be supplied on new contract projects until after the requests for proposal (RFP's) are made available and then only in strict accordance with regulations. This document is not intended to solicit proposals; all unsolicited proposals whose contents reflect the objectives of proposed projects listed herein will be returned without formal review.

PROGRAM OUTLINE

The long-range goal of the Minerals Environmental Technology program is to reduce and ultimately eliminate the adverse environmental effects associated with mining and mineral-processing activities. The program's major objectives are--

1. To develop data and perform analyses necessary to predict and assess the environmental impact of mining and mineral-processing activities.

2. To provide improved technology that can be integrated into mining and process unit operations to prevent or limit the production of substances and conditions harmful to the environment.

3. To develop techniques and methodology to resolve environmental problems arising from past mining and processing practices and provide the assessments and technology necessary to assure optimal land utilization following extraction and processing operations.

The program is conducted by means of both in-house and contract efforts. The in-house effort develops technology through projects that are more efficiently conducted internally and maintains the necessary Bureau expertise to develop, monitor, and guide the contract research to assure the most efficient overall effort.

The Minerals Environmental Technology program is organized into five subprograms. Four of these are described in this publication and are research and development activities: Mine Waste Control, Process Waste Control, Mined-Land Reclamation, and Special Environmental Problems. The fifth subprogram, Mined-Land Demonstration, is an applied technology component involving, for the most part, site-specific public works activities, and is beyond the scope of this paper.

A note on nomenclature: The reader will occasionally observe the use of a series of asterisks (***) following project titles throughout the

publication. In the case of in-house projects, this indicates that the work is new in FY 81. When used with contract titles, it implies that the project (a) was in process of procurement at the end of FY 80 or (b) is a candidate for competitive procurement in FY 81.

Each active project is followed, in parentheses, by the abbreviation of the Research Center responsible for technical performance. In the case of active contract projects, the Center designation is followed by the name of the contractor. Abbreviations for Research Centers are as follows:

ALRC - Albany Research Center
AVRC - Avondale Research Center
BCEL - Boulder City Engineering Laboratory
DRC - Denver Research Center
PRC - Pittsburgh Research Center
RERC - Reno Research Center
RORC - Rolla Research Center
SLRC - Salt Lake City Research Center
SPRC - Spokane Research Center
TCRC - Twin Cities Research Center
TURC - Tuscaloosa Research Center
WO - Washington Office

MINE WASTE CONTROL

Research performed by the Bureau of Mines in the Mine Waste Control subprogram is aimed at providing new and improved technology that can be applied to the Nation's coal, metal, and nonmetal industries for the prevention and control of harmful effects on the environment. The goals are to define the primary environmental problems and to provide new and improved technology that can be used by the mining industry for the prevention and/or control of adverse environmental impacts associated with waste and water management. Specific goals of this subprogram are to--

1. Develop necessary data and information required to determine the state of environmental conditions related to waste and water management.

2. Develop and demonstrate improved techniques for mine waste management and assess their effectiveness.

3. Make available to industry the technical knowledge needed to select, design, and use the most effective control measures developed.

Water Management

The Water Management element of the Mine Waste Control subprogram encompasses both the effects of water quality degradation from mining operations and the effects of mining on the quantity and flow patterns of regional hydro logic regimes. A wide range of research work is performed, ranging from

preliminary studies and data gathering to the development of control techniques and water management plans.

In-House Projects

1. Characterization of Airborne and Waterborne Toxic Elements ***

Objective: To identify and quantify toxic components in airborne and waterborne effluent streams for the Bureau Research Centers doing research in Minerals Environmental Technology. (AVRC)

2. Determination and Evaluation of Impacts of Surface Mining on Hydrologic Systems ***

Objective: To collect baseline data on the impact of surface mining on the hydrologic systems in different mining regions of the country. This will result in an assessment of water management needs. (DRC)

3. Regional Mine Planning for Coal Resource Development While Maintaining Hydrologic Integrity ***

Objective: To identify surface coal mining areas in the Powder River Basin and develop plans for mining with a minimum impact to ground and surface waters. (DRC)

4. Development of Criteria for Predicting the Environmental Effects of Coal Mining

Objective: To continue to develop criteria to predict environmental problems associated with mining specific sites with a given mining method. The work involves assessing hydrological factors including infiltration control and effect of mining on aquifers; examining state-of-the-art limitations by initiating a data base for projected mine areas; and investigating geophysical techniques as potential indicators of areal sulfur variation and acid potential of overburden and coal in surface mining. (PRC)

5. Mine Sealing Studies

Objective: To examine mine sealing programs and techniques, develop new mine sealing technologies, and demonstrate these techniques in practical, pilot or full scale settings. (PRC)

6. Reduction of Water Levels in Anthracite Mines by Surface Diversion, Water Harvesting, and/or Stage Drainage

Objective: To design, develop, and evaluate systems to control surface water infiltration into anthracite deep mines and to control flow patterns within the same deep mines. The study will identify potential sites for application of surface diversions, water harvesting, and/or stage drainage; develop site-specific concepts; and begin baseline monitoring of infiltration-discharge relationships at potential sites. (PRC)

7. Determination of Trace Metals and Priority Pollutants in Coal Mine Effluents and Related Waters ***

Objective: To determine the concentrations of trace metals and priority pollutants in coal mine effluents and the background concentrations in related waters, such as streams and rainwater. (PRC)

8. Pre neutralization Oxidation of Iron in Treatment of Acid Mine Drainage ***

Objective: To develop a treatment method that will rapidly oxidize iron in acid mine drainage, thereby extending the use of limestone as a neutralization agent. (PRC)

9. Inhibition of Iron Oxidizing Bacteria as a Means of Reducing Acid Mine Drainage

Objective: To investigate the feasibility of reducing the acidity of mine drainage by inhibiting Thiobacillus ferrooxidans in acid producing mines and coal refuse piles through the controlled release of anionic surfactants. (PRC)

10. Roof Collapse Procedures To Control Acid Mine Drainage ***

Objective: To evaluate techniques for the control of acid mine discharge by seals created by induced roof collapse. Limiting factors, modes of implementation, and areas of potential application will be assessed. Subsequently, implementation, plans will be prepared for test sites in West Virginia. (PRC)

11. Control of Water Pollution by Removing Silicon Carbide From Granite Sludges ***

Objective: To identify areas of environmental concern related to sawing operations in the granite industry and initiate research to reduce environmental degradation by developing techniques to reduce the amount of material discharged. The research will locate granite-sawing operations, quantify the wastes generated, and sample and characterize the silicon carbide sludges. (SLRC)

12. Preventing Hydrologic Degradation From Phosphate Mining in North Carolina ***

Objective: To determine the environmental effects of extensive pumping on the Castle Hayne aquifer (North Carolina) during phosphate mining. Other determinations include surface effects on land, restoring mined land, and salt water encroachment. Also, research will develop and/or recommend mitigative measures to minimize the problems associated with the pumping. (TCRC)

Contract Projects

1. Monitoring and Modeling of Shallow Ground Water Systems in the Powder River Basin

Objective: To assess and predict the impacts that surface coal mining will have on the regional shallow ground water systems in the basin. Preliminary results indicate that the regional impacts of surface mining on water resources can best be studied by developing a more detailed subregional model. The present computer model of shallow ground water covers the entire structural Powder River Basin and uses finite-difference nodes of 38.6 square miles. At this scale, significant impacts are confined to a few nodes in the model. Thus, present work has been geared to developing this subregional model. (DRC/Hittman Associates)

2. Developing of Dewatering Systems for Surface Coal Mines in the Interior Province

Objective: To develop dewatering methods for possible use in surface coal mines in the Interior Province. Advantages and disadvantages of coal dewatering or ground water control system relevant to surface coal mines in all U.S. coal provinces are discussed. (DRC/Woodward-Clyde)

3. Preparation and Compilation of Geological and Hydrological Information of the Oil Shale Deposits of the Piceance Creek Basin

Objective: To monitor the surface water runoff in Horse Draw for the purpose of determining the degradation in water quality, if any, attributable to the mining environmental research facility activities. (DRC/U.S. Geological Survey)

4. Study of the Hydrology and Water Quality of Watersheds Subjected To Surface Mining

Objective: To determine the hydrologic and water quality effects of surface mining. The study is in its fourth year. Two watersheds have been mined and reclaimed. A third watershed is expected to be mined this year. Erosion plots will go into operation next spring. (DRC/Ohio Agricultural R&D Center and the U.S. Department of Agriculture)

5. Determine the Impact of Longwall Mining on the Hydrologic Balance ***

Objective: To determine the effects of longwall mining on local aquifers and to determine impacts on water quantity and quality.

6. Outcrop Barrier Design for Appalachian Coal Mines

Objective: To provide design criteria for use in planning and designing outcrop barriers that will minimize barrier failures and mine drainage problems. Research will involve the design of outcrop barrier widths, potential

problems associated with impounding large volumes of water in an abandoned bituminous coal mine, outcrop grouting, and measures necessary to prevent seepage through a coal barrier. (PRC/ Dames and Moore)

7. Water Handling Procedures for Reducing Acid Formation in Underground Mines

Objective: To identify and describe the most effective and economic methods for controlling drainage in underground coal mines in order to minimize the formation of acid and iron pollutants and provide mine drainage guidelines to mine operators in the Appalachian coal mining region. (PRC/ Skelly and Loy)

8. Treatment of Mine Drainage From Abandoned Mines by Biological Iron Oxidation and Limestone Neutralization ***

Objective: To develop a sphagnum bog in an already-existing acid water pond; to construct a limestone rubble pile downstream; and to monitor water flow and quality upstream and downstream of the bog and of the limestone pile. It has been shown that dissolved iron is removed naturally from acid mine drainage by ion exchange and precipitation (as ferric hydroxide and iron sulfide) after flowing through a sphagnum moss bog. Removal of the iron before neutralization will eliminate armoring of limestone, thus resulting in low-maintenance neutralization. Although this method would be limited to relatively low-flow situations, its low cost would allow its use in drainage from many abandoned mines and gob piles.

9. Impact of Mining on Ground Water in the Globe-Miami Copper Mining District

Objective: To assess the effects of mining on the ground water quality, quantity, movement, and availability in the Globe-Miami copper mining district. A determination shall be made of the impact due to various mining techniques and practices. The results will be used to determine the seriousness of the problems and the necessary corrective actions. Results from the study will lead directly into Bureau R&D for remedial action to unacceptable environmental impacts. (SPRC/Central Arizona Association of Governments)

10. Monitoring of Ground Water in the Tucson Copper Mining District ***

Objective: To monitor and analyze ground water data in the Tucson copper mining district, and develop a further basis for water management decisions. Parameters to be monitored shall include water quality, quantity, and direction of flow. The analysis will involve the description of the vadose zone, unsaturated flow, ion absorption, and containment transport for the past, present, and future.

11. Predicting Mine Water Inflows and Impact on District Hydrology

Objective: To develop and validate method(s) for predicting mine water inflow by improving interpretation of flow system parameters, and a method for

determining surface and ground water depletion relative to mine water inflow. (SPRC/Williams, Robinette and Associates)

12. Development of Environmentally Attractive Leachants

Objective: To determine the optimum constituents from several candidates for leachants used in extracting uranium from sandstone uranium ores. It is anticipated that the new leachant will facilitate the restoration of the ground water quality after leaching. (TCRC/ University of Texas)

13. Impact of Proposed Lignite Mining in West Tennessee

Objective: To investigate the feasibility of mining western Tennessee lignite with respect to ground water, soil resources, and slope stability in the area. The hydrologic system shall be investigated to anticipate potential environmental problems that might crop up as a result of future lignite mining in the area. The base-line water resources data shall be organized into a computer data retrieval system. From this, predictions can be made; and then during and after mining, assessments can be made of the impact on water resources in the study area. (TCRC/Vanderbilt University)

14. Water Supply and Pollution Problems Associated With the Mesabi Range Iron Ore Mining Industry

Objective: To examine current iron range water problems. Areas of major environmental concern are being identified, and future research shall be recommended. The water requirements, use, and disposal for iron mining are being surveyed. (TCRC/Uintex)

15. Monitoring of the Impact on Ground Water Hydrology of Borehole Mining of Phosphate Ores

Objective: The U.S. Geological Survey is monitoring the quantity and quality of the ground water in the vicinity of the phosphate mining operations. The monitoring is taking place in the Floridian aquifer below the level of the mining operation, in the Hawthorne Formation at the level of the phosphate bed, and in aquifers above the level of the mining operations. A data report shall be submitted stating the hydrological changes, if any, that occur as a result of the borehole phosphate mining. (TCRC/U.S. Geological Survey)

16. Biological Oxidation of Iron by Thiobacillus Ferrooxidans in a Sequencing Batch Reactor

Objective: To investigate the biological oxidation of ferrous iron by Thiobacillus ferrooxidans in the presence of particulate settling aids under conditions representative of acidic mine waters and to develop a mathematical model of the process. (TCRC/Notre Dame University)

17. Development of a Dewatering System for Controlling Fracture-Dominated Inflow for Acid Mine Drainage Abatement

Objective: To design and field-test a pilot-scale fracture dewatering system for acid mine drainage abatement. Acid mine drainage (AMD) from coal mines is a major pollutant of streams and rivers. Treatment of mine drainage has thus far been the principal means of combating this degradation of surface water, while preventive control of AMD is a promising but largely untested alternative. The method of dewatering from within the mine has several technical and environmental advantages over effluent treatment. Control of fracture inflow in wet mines can reduce the volume of mine drainage requiring treatment by 60 percent with a resultant decrease in the capacity requirements of the water treatment plant. (TCRC/Skelly and Loy)

18. Investigation of the Mechanics of Mine Acid Formation in Underground Coal Mine Drainage

Objective: To investigate through the use of laboratory experiments the extent of biological catalysis of pyrite weathering using fresh mine face samples and under conditions simulating mine conditions. Sufficient mines and mine samples were examined to provide data that were generalized for the total acid-producing coal mine population in the Appalachian States. Recommendations were made on possible methods to inhibit the oxidation of pyrites. (TCRC/ECO-Control, Inc.)

19. Analysis of Ground Water Criteria and Recent Restoration Attempts After In Situ Uranium Leaching

Objective: To present, compile, and compare the criteria for ground water restoration and the effectiveness and costs of the methods employed, to develop empirical expressions, to predict the amount of aquifer flushing required, and to improve predictions of the cost of restoration. (TCRC/Resource Engineering and Development)

20. Effects of Coal Mine Subsidence on Ground Water Aquifers in Northern Appalachia

Objective: To provide a comprehensive hydrogeologic record of the changes in the ground water systems, above and adjacent to a room-and-pillar section and also above and adjacent to an active longwall section as subsidence occurs. (PRC/Science Management Engineering)

21. Minimization of Ground Water Contamination in Surface Mine Backfill

Objective: To determine the thickness of clay seals and spoil density requirements and to determine how effective they are in preventing acid mine drainage. (SPRC/Penn State University)

22. Ground Water Resources in Relation To Surface Mining for Coal

Objective: To assess the impacts of surface mining on ground water and place these impacts in context with other types of disturbances to ground water resources. Also to determine the state of the art in control technology. (SPRC/National Academy of Sciences)

23. Control of Water Pollution From Surface Mining Operations

Objective: To identify ground and surface water management and control problems related to surface mining in the United States where water pollution is a problem. Conceptual water management plans shall be developed for such problems as aquifer disturbance, pit dewatering or mine drainage, and site abandonment. (SPRC/Wapora)

Solid Waste Management

The Solid Waste Management element of the Mine Waste Control subprogram addresses a wide spectrum of research including baseline studies, inventories, material property characterization, waste handling and placement methods, systems design, embankment stability, waste utilization, and long-term environmental stability. Existing and proposed standards resulting from the Surface Mining Control and Reclamation Act and the Resource Conservation and Recovery Act have made mine waste management one of industry's primary concerns in the environmental area. Although some technical basis now exists for compliance with legal requirements, additional research is needed in all areas of surface and underground waste disposal, including alternative means of waste utilization, so that the domestic industry can remain viable in the face of increasingly restrictive performance standards.

In-House Projects

1. Control of Hazardous Alkalies From Cement Kiln Dust ***

Objective: To eliminate an environmental problem in cement production from the alkali and the alkali-free materials. Presently, 6 to 10 million tons per year of kiln dust is discarded to dumps or land fills, because alkali renders the dust unsuitable for cement. The discarded dust is a hazardous waste because the alkali can leach out and contaminate ground water. (ALRC)

2. Characterization of Potential Manganese Nodule Processing Rejects ***

Objective: To verify, improve, and update the information available on manganese nodules, to clarify some of the terminology used in identification and characterization of nodules and their processing reject materials, and to prepare representative manganese nodule reject materials for future study. The source of funds for this project is via Interagency Agreement with the National Oceanic and Atmospheric Administration. (AVRC)

3. Tailings Pond Research and Testing Facility

Objective: To continue the pond liner testing program on samples installed in industrial ponds. Samples will be removed and tested for properties such as permeability and tear strength. Several new liners will be installed in operating ponds. Also, dewatering techniques such as sand bed drainage and capillary assisted evaporation will be tested. (BCEL)

4. Controlled Burnout of Coal Waste Bank Fires at the Moss No. 1 Plant

Objective: To assist in technology transfer of the concept of controlled burnout of a fire in a coal waste bank utilizing Bureau of Mines developed in situ combustion methodology. (PRC)

5. Controlled Burnout of Fire at Abandoned Coal Mines - Calamity Hollow

Objective: To demonstrate the concept of controlled burnout of fire in an abandoned coal mine by utilizing Bureau of Mines methodology for in situ combustion to deplete the fuel responsible for the fire in an environmentally sound manner and with utilization of the heat produced. (PRC)

6. R&D Support for Burnout Control of Fires on Abandoned Coal Mine Lands

Objective: To develop analytic models for controlled burnout, improve methods of high temperature borehole construction and instrumentation for monitoring burnout control, and evaluate burnout control for coal wastes. The latter two items will involve activities in the Bureau's surface trench burn facility. (PRC)

7. Abating Pollution From Lead Tailings Piles in Southeast Missouri ***

Objective: To examine lead mine tailings ponds in the southeast Missouri lead belt to characterize the nature and magnitude of compositional and physical makeup of contaminating constituents and to assess potential methods of rendering these tailings environmentally safe to regional surface and ground water systems. (RORC)

8. Pollutant Identification in Auto Shredder Offal Material ***

Objective: To select from a number of shredders samples of fluff and other residues that are commonly disposed of in landfills throughout the country. Samples will be subjected to chemical analysis and handpicking to determine their chemical and physical makeup. Samples will also be leached according to proposed EPA standards and the leachate analyzed to determine its composition. (SLRC)

9. Physical and Chemical Characteristics of Manganese Nodule Processing Wastes

Objective: To obtain samples of manganese process waste from the Avondale Research Center. Laboratory tests will be performed on these wastes to

determine eight materials properties: Composition - mineral and chemical, permeability, settling rate, size distribution, specific gravity, density, electrical conductivity, and strength. (SPRC)

10. Improved Hydraulic Method for Coal Waste Disposal

Objective: To provide an improved method of waste disposal by providing economical slurry transport and a stable blended waste. Present methods of handling coal refuse include sludge disposal ponds for fine coal refuse (which are hazardous because of the hydraulic properties of the material) and coarse waste dumps (which tend to ignite because of porous nature of the embankments). Recently, some coal-cleaning plants have installed dewatering devices for the fine refuse and combine the coarse and dewatered sludge prior to disposal. The procedure is extremely expensive, produces a "bulked" material disposal (which has poor long-term stability characteristics), and presents materials-handling problems. (SPRC)

11. Development and Evaluation of Waste Disposal Plans and Techniques

Objective: To identify major waste management problems through meetings with industry representatives, maintain industry contacts, and perform background and preliminary research in the development of new research projects. (SPRC)

12. Waste Water Monitoring Techniques for Uranium Tailings

Objective: Seepage from uranium tailings has been a quite controversial subject between regulating agencies and industry. Certain proposed regulations could have a drastic effect on the economics of uranium mining. Many uncertainties are due to the many unknowns in water quality, quantity, and movement in the disposal vicinity. This effort is to simplify and improve data-gathering techniques to improve the state of the art and provide a basis on which realistic regulations may be promulgated. In this case the benefit would apply to industry as well as to applicable regulatory agencies. (SPRC)

13. Designs of Slime-Sealed Impoundments To Prevent Ground Water Contamination

Objective: To use mill tailings and/or natural soil rather than fabric liners to reduce seepage in tailings impoundments. Laboratory permeability testing of mill tailings and natural soil within a tailings area in combination with additives and compaction techniques will determine potential methods for reducing the seepage beneath tailings ponds. These results will then be transferred to field tests where the actual seepage for a given area is measured. (SPRC)

14. Survey Foundry Wastes in Southeastern United States To Identify Environmental Hazards ***

Objective: To initiate a systematic program to identify the various types of waste materials generated by foundries in the Southeast, to determine

whether they currently or potentially pose environmental hazards, and to recommend research to alleviate any problems. (TURC)

15. Assessment of Environmental Impacts Associated With Byproduct Gypsum Stacks From Florida Phosphates

Objective: To determine the extent and nature of radiation-related and other environmental problems associated with the disposal and subsequent leaching of byproduct gypsum, and recommend and initiate research to alleviate the problem. (TURC)

16. Borehole Mining Cavities for Disposal of Radioactive Mine Wastes

Objective: To investigate aspects of rock mechanics, environmental engineering, safety engineering, economics, and nuclear energy regulation relative to adaptation to the Bureau borehole mining technology to the construction of storage cavities for solid wastes generated in uranium in situ leaching operations. (TCRC)

Contract Projects

1. Containment Pond Liner Materials Testing ***

Objective: To determine performance of typical liner materials under actual industrial service. Liners shall be installed in operating ponds and tested for material properties such as permeability and tear strength at various time intervals.

2. Demonstration and Evaluation of Underground Disposal of Coal-Mining Wastes

Objective: To conduct a 1-year demonstration of a system(s) of underground disposal of coal-mining wastes in an active underground coal mine. The project final report shall include an assessment of the technical problems and economics of implementation of a total system of underground disposal of coal-mining waste in an active underground coal mine. (DRC/GEX Colorado and Foster-Miller)

3. Design and Engineering of a Burnout Control System for a Coal Waste Bank ***

Objective: To attempt the controlled acceleration of a fire by air injection so that complete fuel burnout is accomplished in a time period that is short compared with the many decades that such fires could propagate if left unattended. Injection of air into and removal of combustion products from the waste bank would be accomplished by a surface exhaust ventilation system operating through boreholes extending into the banks.

4. Fly Ash and Byproduct Gypsum as Mine Backfilling ***

Objective: To examine lead mine tailings piles in the southeast Missouri lead belt to characterize the nature and magnitude of compositional and physical makeup of contaminating constituents and to assess potential methods of rendering these tailings environmentally safe to area surface and ground water systems. Characterization of selected lead tailings piles shall be made through comprehensive chemical and physical analyses. Samples shall be taken to determine where and to what degree segregation and distribution have occurred in the piles. Research shall be supplemented with initiation of an evaluation to delineate potential extraction processes for removal of the hazardous and valuable constituents from the tailings piles. Initial emphasis shall be placed on the large tailings pile at Desloge, Mo., because of the critical environmental condition (tailings runoff into the Big River) that now exists. There are approximately a dozen tailings piles in this southeast Missouri area, each containing approximately 10 to 50 million tons of material.

5. Developing a Slurry Fill for Modified In Situ Oil Shale Mining

Objective: To develop an underground slurry filling system that will minimize surface and underground environmental disturbance. Specifically, to render in situ shale rubble virtually impermeable and minimize contamination of the ground water and its aquifers, to bind the spent shale together in a coherent mass sufficiently strong to resist surface subsidence and eliminate the potential for differential settlements of the surface, and to dispose of the maximum amount of surface retorted shale material as the major constituent of the fill, thereby minimizing or eliminating disposal of spent shale on the surface. (SPRC/Rio Blanco Oil Shale Co.)

6. Development of Systematic Waste Disposal Plans

Objective: To develop a set of guidelines for the mining industry that provides rationale for the development of systematic waste disposal plans. The resulting document (manual) will be suitable for use by Federal and State personnel, mine operators and planners, and design professionals. Emphasis shall be placed on the impact of a disposed waste on all aspects of the environment, including, but not limited to, future land use and economic factors, long-term stability, hydrology effects, potential contamination of water supplies, and emanation of hazardous substances. Impact of existing and proposed State and Federal regulations on the disposal of waste shall be emphasized as well. (SPRC/Goodson and Associates)

7. Mine Waste Location by Satellite Imagery

Objective: To investigate the potential for using satellite (Landsat) data for detecting coal, metal, and nonmetal waste and tailings disposal sites. The contractor shall determine if the band-ratio method of preprocessing the Landsat multispectral data before classification can be used to detect and identify waste embankments. (SPRC/Science Systems and Application, Inc.)

8. Engineering Property Changes and Environmental Effects on Coal Mine Waste Due to Slaking

Objective: To determine the changes in physical properties and chemical environmental impact potential of coal mine waste dumps and embankments as a function of age, and to evaluate the effects of slaking on the stability of waste piles and recommend techniques to control the detrimental changes. (SPRC/W. A. Wahler)

9. Conceptual Designs for Retaining Structures for Open Pit Backfilling

Objective: To develop conceptual designs of retaining structures for constructing backfill areas to dispose of wastes within open pits. Milling, smelter, and overburden wastes shall be considered. Detailed conceptual designs shall be developed for two operating open pit mines. (SPRC/Skilling, Helle, Christiansen and Robertson)

10. State-of-the-Art Environmental Assessment of Onshore Disposal of Manganese Nodule Rejects

Objective: To identify all reasonable state-of-the-art and emerging techniques for the onshore disposal of various types of manganese nodule rejects and to develop site-selection design criteria and associated significant environmental and land use effects for those techniques, sites, and types of rejects identified. (SPRC/Rogers, Golden, and Halpern)

11. Evaluation of Lixiviation of Mine Wastes

Objective: To determine which types of, and to what extent, coal wastes contaminate ground water through leaching of acid-forming or toxic-forming materials. The completion of this program shall involve field sampling to collect solid wastes samples and a laboratory study to evaluate the extent to which components of these wastes are leached by rainwater. (SPRC/Calspan)

12. Field Test for Environmental Disposal of Mill Tailings in Surface Backfill

Objective: To perform a small-scale field test to dispose of mill tailings along the Coeur d'Alene River valley while preventing seepage through the waste and into the water system and to conduct geotechnical, hydrologic, and vegetative experiments at the site and evaluate feasibility of full-scale implementation. (SPRC/Greater Shoshone County)

13. Investigations of the Flow Characteristics of Mine Tailings

Objective: To determine the flow characteristics of liquefied mine tailings, and the probable extent of travel when a mass of mine tailings flows and liquefies. Case studies of mass flow failures of mine waste embankments shall be back-analyzed. (SPRC/University of California)

14. Designs for an Underground Disposal System for Active Uranium Mines ***

Objective: To define the backfilling constraints, including environmental constraints, stability constraints, health and safety constraints, and regulatory constraints, and then to develop a number of initial conceptual designs based on the work performed in related contracts and other pertinent information. In the final phase, the contractor shall develop a detailed design at a specific site.

15. Disposal of Gold Dredge Tailings ***

Objective: To develop and demonstrate methods to partially level the ridges of coarse gravel left by the dredge waste conveyor and pump the finer gravel, sand, and soil onto the smoothed area. This would eliminate ridges of sterile, washed, coarse gravel that exist from present methods of operation and place the topsoil on the surface in a usable condition.

16. Inventory of Waste Embankments, Surface and Underground Openings

Objective: To compile an inventory of mine waste embankments, forming a data base for improving waste management and waste disposal techniques in the metal and nonmetal mining industry. (SPRC/Mountain States R&D)

17. Use of a Finite Element Code for Analysis of Seepage From Tailings Ponds ***

Objective: To develop and demonstrate a computer code capable of analyzing seepage from tailings ponds under partially saturated conditions in the foundation soil. Analytical results obtained from the program shall be compared with field measurements for verification of output data.

18. Measurement of Seepage Beneath Tailings Ponds

Objective: To apply the results of the in-house project "Design of Slime-Sealed Impoundments To Prevent Ground Water Contamination" to field conditions where seepage can be accurately measured to determine the best possible method for sealing the bottom of the tailings pond to prevent seepage. Five separate areas are being prepared to test different combinations of natural soil-tailings and compaction to achieve the desired results. (SPRC/ASARCO)

19. Removing Heavy Metal From Runoff Water Draining Lean Copper-Nickel Ore Stockpiles

Objective: To develop techniques for removing heavy metal pollutants from runoff draining copper-nickel lean ore and waste stockpiles. The development of copper-nickel resources in northeast Minnesota depends upon the selection of an adequate abatement program to control heavy metal leaching from exposed waste rock and lean ore piles. The low grade of the ore deposit makes it necessary to find an inexpensive control system which will allow the

mining to be economically feasible. (TCRC/Minnesota Department of Natural Resources)

20. Grouting Methods To Prevent Ground Water Contamination From Dump and In Situ Leaching ***

Objective: To evaluate the technical and economic feasibility of using a blasted presplit fracture plane, injected with grout, to form a grout curtain to contain leach solutions in conjunction with dump and in situ leaching operations.

21. Sample Mining and Milling Wastes in the Southeastern United States To Identify Environmental Hazards ***

Objective: To initiate a systematic program to identify the various types of waste materials generated by foundries in the Southeastern United States, determine whether they currently or potentially pose environmental hazards, and recommend future research to mitigate problem areas. Foundry waste may contain environmentally hazardous substances that need to be disposed of in an environmentally sound manner. Some wastes may be treated and returned to the foundry for reuse, thereby eliminating part of the disposal problem. The data obtained by this research are essential to establishing information concerning these wastes and their potential for environmental degradation. The technology developed from this research will allow the foundry industry to meet EPA regulations pertaining to mineral waste discharges.

22. Assessment of Ground and Surface Water Effects Around Coal and Mineral Storage Areas

Objective: To survey the extent to which storage piles of coal and minerals release toxic ions or other significant organic pollutants to ground or surface waters and to assess pollution types and levels and then develop mitigative measures for each mineral commodity for improved control of runoff. (TCRC/Hittman Associates)

23. Detection of Lixiviant Excursions With Geophysical Resistance Measurements During In Situ Leaching

Objective: To develop, test, and demonstrate a geophysical resistance measuring system that can reliably detect the excursion of a lixiviant having a resistivity half that of the ground water it replaces when the lixiviant has migrated halfway from an injection well to a monitor well at a depth of at least 500 feet. (TCRC/Westinghouse Electric Inc.)

24. Evaluation of Best Management Practice for Mining Solid Waste

Objective: To determine best management practices for mine waste disposal in the areas of ore (copper, iron, lead, nickel, molybdenum, and zinc), phosphates, and uranium by utilizing the results of an extensive monitoring

program for ground and surface water and air quality. (WO/Pedco Environmental Inc.)

PROCESS WASTE CONTROL

This subprogram's overall goal is to provide the expeditious advances in technology needed to alleviate the environmental problems caused by the processing of minerals. Specific goals of this subprogram are to--

1. Quantify environmental problems relating to the processing of minererals.

2. Develop and evaluate technology for minimizing release of environmental contaminants and their associated effects.

3. Demonstrate new technology on a scale of sufficient magnitude to assess its effectiveness.

4. Disseminate technical knowledge for the use of the minerals industry and regulatory authorities.

Effluents and Emissions Control

This element's overall goal is to provide new and improved technology for the treatment of effluents and emissions that result from the processing of minerals. Specific goals of this element are to--

1. Develop procedures for the removal and recovery of sulfur dioxide and other volatiles from process emissions.

2. Develop procedures for the treatment of process waters to remove and recover soluble toxic elements and compounds and to recycle the process water.

3. Develop procedures for the removal of particulates from slimes and suspensions, to recycle the released water, and to utilize the dewatered solids for land reclamation.

4. Transfer this technology to the industry through field demonstrations, films, publications, patents, and other appropriate means.

In-House Projects

1. Cleanup and Recycle Technology for Mine and Mill Waters

Objective: To devise process water treatments that permit water reuse or safe discharge and recover minerals and metals contained in the waters. (SLRC)

2. Environmental Control of Mineral-Processing Reagents

Objective: To determine the fate of mineral-processing reagents and their decomposition products and to evaluate their effect on mineral-processing systems and on environmental quality. (SLRC)

3. Citrate Process: Chemistry and Engineering

Objective: To evaluate the effectiveness of changes in the citrate process for scrubbing sulfur dioxide from gas streams. Investigations of the stream stripping of sulfur dioxide from citrate solutions at elevated temperatures and pressures will be completed. Pilot plant support for the demonstration plant will be provided. (SLRC)

4. Citrate Process: Stack-Gas SO_2 Scrubbing

Objective: To test and evaluate a prototype plant to demonstrate the Bureau's citrate process for removing sulfur dioxide from stack gases of powerplants. To monitor the performance testing and demonstration operation of the new facility at St. Joe Minerals Corp. in Monaca, Pa., and Radian Corp.'s research contract for testing and evaluation of the facility. Laboratory backup for the demonstration project will be provided. (SLRC)

5. Modification of Mineral Processing Wastes

Objective: To devise technology to render mineral-processing solid wastes satisfactory for safe discard by removal and, where possible, recovery of toxic substances contained in the wastes. A scheme for the removal and recovery of arsenic and metal values from arsenical lead and copper smelter flue dusts is being developed. The process will be tested in a 1-pound-per-hour process investigation unit. (SLRC)

6. Evaluating Desliming Techniques

Objective: To evaluate mechanical desliming techniques for the metal and nonmetal minerals processing industry. (SPRC)

7. Water Recovery From Phosphate Clay Slimes

Objective: To develop and evaluate new flocculating agents and dewatering devices and to compare the polyethylene oxide dewatering technique with other methods. Emphasis will be placed on process improvement utilizing a field test unit on site at White Springs, Fla. The suitability of the water released for reuse will be investigated. The suitability of the dewatered solids for permanent land reclamation will be assessed. (TURC)

8. Consolidation of Mineral Wastes To Eliminate Potential Environmental Problems

Objective: To develop procedures for the dewatering of nonphosphate mineral-processing wastes. Available and new flocculents will be evaluated

for the consolidation of slimes such as are obtained from the processing of potash, talc, and titanium dioxide and from drilling mud and metal hydroxide sludges. (TURC)

9. Dewatering and Detoxication Technology

Objective: To monitor contracts J0100119, "Use of a Baffled Rotating Tubular Reactor in the Flocculation Dewatering of Florida Phosphatic Clay Waste" (University of Nevada); J0199150, "Microbial Flocculation of Phosphate and Potash Slimes" (New Mexico Institute of Mining and Technology); and J0100127, "Detoxication of Arsenic and Characterization of Organic Compounds Produced by Roasting of Phosphates" (Spelman College). (TURC)

10. Removal of Particulates and Slimes From Mineral Processing Water

Objective: To devise new methods for treating mineral-processing waters and effluents by using oppositely charged solids as contact filters for removing suspended particulates, by substituting magnesium oxide for lime in removing dissolved heavy metals, and by developing a procedure to detoxify cyanide-containing solutions by converting cyanide to particulate forms. (TCRC)

11. Treatment of Solvent Extraction Emulsions

Objective: To develop techniques to promptly break refractory solvent extraction emulsions, thereby freeing reagents for recycle, freeing dissolved values for recovery, and alleviating the problem of containment and disposal of a hazardous waste. (TCRC)

Contract Projects

1. Effect of Thiobacillus Ferroxidans on the Weathering of Tailings

Objective: To determine the effect of bacteria on the weathering of chalcopyrite or lead-zinc leach tailings with emphasis on tailings generated by ferric chloride or chlorine-oxygen leaching. (RERC/University of Nevada-Reno)

2. Demonstration of the Citrate Process SO_2 Removal System

Objective: To design, construct, and operate for a demonstration year, a plant for the removal of SO_2 from stack gases of the 50-megawatt George F. Weaton powerplant at Monaca, Pa. Design capacity is 156,000 scfm of 0.2 volume-percent SO_2 yielding 16 tons of sulfur per day. (SLRC/St. Joe Minerals Corp.)

3. Testing and Evaluation of Citrate Process Demonstrations

Objective: To provide independent testing and evaluation of the citrate process demonstration plant (item 2, above) to judge economic viability of the process. (SLRC/Radian Corp.)

4. Interaction of Acid Mine Water and Concentrator Waste

Objective: To improve waste water treatment by modeling the mixing of alkaline copper concentrator tailings slurry with concentrator waste water to precipitate soluble metals from these waste streams. (SLRC/Montana College of Mineral Science and Technology)

5. Use of a Baffled Rotating Reactor in the Flocculation Dewatering of Florida Clay Wastes ***

Objective: To make an engineering study of the use of baffled tubular reactors for mixing flocculant and slimes and simultaneous water removal. Critical parameters shall be measured for the use of a single piece of rotary equipment for both mixing and water removal.

6. Detoxication of Arsenic and Characterization of Organic Compounds Produced by the Roasting of Phosphates

Objective: To identify enzyme systems capable of detoxifying arsenic by searching liver tissue and intestinal flora and to identify and assess the toxicity of organic compounds driven off during the roasting of North Carolina phosphate ore. (TURC/Spelman College)

7. Microbiological Flocculation of Phosphate and Potash Slimes

Objective: To isolate organisms capable of flocculating slimes and to develop an economic nutrient source for these organisms. (TURC/New Mexico Institute of Mining and Technology)

Accessory Minerals Control

The overall goal of this element is to develop modifications to minerals treatment processes in order to control the fate of accessory minerals during processing so that they may be recovered or disposed of safely. Specific goals of this element are to--

1. Develop procedures for determining the fate of and the partitioning of accessory elements and compounds during mineral processing.

2. Develop and test models of major metallurgical processes and use them to evaluate the fate of accessory elements.

3. Develop and test process modifications to direct accessory elements during metallurgical processing.

4. Transfer this technology to the industry through field demonstrations, publications, patents, and other appropriate means.

In-House Projects

1. Minerals Recovery From Copper-Smelting Slags

Objective: To determine the distribution of minor, potentially toxic, elements such as arsenic, antimony, bismuth, selenium, and tellurium between matte and slag as a function of slag composition and operating conditions and recommend methods for concentrating these elements in the slag for possible recovery. Both conventional and flash smelting will be explored. (ALRC)

2. Trace Analysis and Molecular Species Determination of Accessory Elements

Objective: To identify and characterize accessory compounds which are volatilized during pyrometallurgical operations. Knudsen cell and mass spectrometer measurements will be made to identify volatile-sulfur-containing species of arsenic, antimony, and bismuth. (ALRC)

3. Recovery and Control of Accessory Minerals in the Processing of Titanium and Zirconium Ores

Objective: To characterize, recover, and control accessory minerals in residues generated by industrial processing of titanium- and zirconium-bearing materials. (ALRC)

4. Accessory Minerals Distribution in Lead Smelting ***

Objective: To determine the distribution of As, Cd, Ti, In, Se, and Sb between lead bullion and slag as a function of slag composition and temperature. (ALRC)

5. Thermodynamic Data for Accessory Mineral Control ***

Objective: To provide thermodynamic data on hazardous accessory minerals and compounds. Thermodynamic data will be critically evaluated, estimated, and compiled for arsenic-sulfur compounds. (ALRC)

6. Pyrometallurgical Technology

Objective: To monitor contract J0295956, "The Concentration of Inpurity Elements From Copper Reverberatory Slags" and related contract projects. (ALRC)

7. Characterization of Accessory Minerals

Objective: To establish the nature and occurrence of accessory minerals and elements in process wastes and feeds. Investigations are being carried out on cement kiln dust and materials bearing uranium, fluoride, and radium from phosphate operations. (AVRC)

8. Application of Inorganic Ion Exchangers to Metallurgy

Objective: To develop methods for using inorganic ion exchangers for removing toxic elements and recovering valuable accessory elements from mineral processing waters. (RERC)

9. Recovery of Accessory Minerals in Hydrometallurgical Processes

Objective: To determine the distribution of accessory elements during hydrometallurgical processing steps and to enhance their recovery by in-process alterations. (RERC)

10. Physical Chemistry of Metallurgical Process Engineering

Objective: To apply the principles of physical chemistry to analyze the distribution and disposition of accessory elements and compounds in metallurgical operations and to employ mathematical models of metallurgical processes to predict process changes that would yield better neccessory element control and high metal recoveries. (RERC)

11. Control and Recovery of Accessory Minerals in Lead and Zinc

Objective: develop environmentally acceptable hydrometallurgical techniques for recovering accessory and other values from smelter and refinery byproducts. (RORC) 12.

12. Control of Radioactive Accessory Minerals in Phosphate Flotation Tailings ***

Objective: To investigate techniques for the removal of radioactive-bearing minerals, such as heavy minerals and rare earth compounds, from phosphate flotation tailings, thereby eliminating environmental hazards during land reclamation. (TURC)

13. Petrographic Characterizations

Objective: To monitor contract J0100015, "Characterization of Accessory Minerals in Birmingham Red Iron Ores and Eufaula Ferruginous Bauxite Deposits in Alabama." (TURC)

14. Control of Toxic Elements in Leaching Processes and Waste Streams

Objective: To minimize the environmental effects of copper leaching by identifying parameters that can be used to control the solubility and mobility of toxic elements such as arsenic and selenium and to determine the potential of lignochemicals and humic acids for removing toxic elements from processing and waste streams. (TCRC)

15. Control of Leachable Accessory Elements From Waste Ferrous Slags ***

Objective: To develop high-temperature slag-to-slag extraction procedures to remove extractable potentially toxic elements from waste ferrous slags, to reduce the volume of hazardous slag that must be discarded, and to treat slags to lock in pollutants. (TCRC)

Contract Projects

1. Determination of the Chemical Form and the Activity Coefficient of As, Bi, and Se in Copper Metallurgical Slags ***

Objective: To determine the activities of trace elements in slag and white metal as a function of slag composition for basic slags and as modified with silica and magnetite. Implications for conventional and flash smelting shall be evaluated.

2. Concentration of Impurity Elements From Copper Reverberatory Slags

Objective: To determine the form and distribution of arsenic, antimony, bismuth, selenium, and tellurium in copper reverberatory slags as a first step in evaluating techniques for controlling the distribution of these elements in slags and mattes. (ALRC/University of Nevada)

3. Characterization of Accessory Minerals in Birmingham Red Iron Ores and Eufaula Ferruginous Bauxite Deposits in Alabama

Objective: To identify the mineral association of accessory elements in Birmingham iron ores and Eufaula bauxite by petrographic examination. (TURC/University of Missouri)

MINED-LAND RECLAMATION

This subprogram's overall goal is to develop new and improved technology that can be used by the minerals industry for the prevention of the undesirable environmental effects of minerals extraction and processing. Research conducted addresses both short- and long-term solutions to environmental effects associated with reclamation of land utilized during minerals extraction. Specific goals of this subprogram are to--

1. Develop and demonstrate methods for segregation, storage, and placement of topsoil, techniques for selective handling of toxic overburden, and equipment systems for contour restoration.

2. Develop and demonstrate methods for stabilizing restored topsoil and overburden, spoil piles, tailings ponds and embankments, and highwalls.

3. Develop and demonstrate techniques for subsidence prediction, control, and prevention, and subsidence damage abatement.

4. Determine mining and reclamation practices that offer optimum post-mining surface utilization.

Land Restoration

The Land Restoration element addresses environmental problems that occur during and immediately after the extraction of the mineral commodity as well as the stabilization of minerals-processing waste. The goal is to develop mining, reclamation, and minerals-processing techniques that, when adopted, will result in mineral land being used for the highest potential beneficial land use after extraction is completed. Work is categorized into the following areas: Land use, reclamation methods, recontouring methods, reclamation systems development, soils relationships, and restoration equipment. Some of the element objectives are to--

1. Develop analytical techniques for conducting alternative postmining land use evaluations.

2. Develop and demonstrate techniques and equipment to test and evaluate the effectiveness of reclamation methods.

3. Develop and demonstrate techniques that support mining and reclamation environmental regulations.

In-House Projects

1. Identification of Revegetation Problems in Arid and Semiarid Surface Metal and Nonmetal Mining Regions

Objective: To identify problems in revegetating arid and semiarid disturbed areas and recognize plant communities that are productive and adaptable to a disturbed mine condition. Problems in metal and nonmetal mined areas will be surveyed and categorized for both surface and underground mines. (DRC)

2. Reclamation of Tailings in Subalpine Environments ***

Objective: To conduct a literature review to document the success of revegetating and/or stabilizing tailings in subalpine environments. Field sampling measurements will be taken on reclaimed sites at a uranium mine to determine which revegetation procedures were successful. (DRC)

3. Surface Mine Reclamation Technology

Objective: To provide planning and assistance on program development in Land Restoration when work requires preparing RFP's and evaluating USP's, reviewing manuscripts, negotiating contracts, monitoring contract research, and transferring technology to industry. (DRC)

4. Research Management and Planning Systems (RMAPS)

Objective: To provide the Office of the Deputy Director for Minerals Research, and/or on request any other groups in cooperation with Minerals Research, information, assistance, and/or reports containing useful and timely data to assist them in their work. (DRC)

5. Determination of the Long-Term Effects of Reclamation of Surface Mine Spoils and Refuse Areas Using Powerplant Fly Ash ***

Objective : To sample previously established plots, perform chemical analysis of soils, water, and plant tissue, and correlate the long-term conditions to those existing at time of treatment and immediately following treatment. The project constitutes a 10-year evaluation of the fly ash spoil reclamation procedures developed by the Bureau. (PRC)

6. Surface Restoration of Minerals-Processing Wastes

Objective: To devise, improve, and field-test methods for stabilizing mining and minerals processing wastes and evaluate their effectiveness in minimizing air and water pollution or other adverse environmental impacts. Work for FY 81 includes (1) continue cooperative contract research with the U.S. Department of Agriculture Crop Research Center, Logan, Utah, to select and test plant materials for mined-land reclamation, (2) continue irrigation and monitoring of 50-acre Bauer, Utah, field test to obtain quantitative data on the effect of reclamation on environmental pollution, (3) continue research on steep slope reclamation methods and initiate design work through a contract for specialized equipment needed to treat and plant such areas, (4) continue research to enhance the ability of selected plants to fix nitrogen through amendments or bacterial inoculation, (5) continue cooperative environmental research on specific residues generated by pilot operations using Bureau of Mines devised metallurgical processing methods, and (6) continue evaluation of past reclamation field test. (SLRC)

7. Effects of Topsoil Stockpiling and Water Collection Systems on Mined Land Reclamation in Arid Climates

Objective: To determine the effects of stockpiling of topsoils on soil fertility and compare small-scale and overall fertility. Field tests will be established using water collecting techniques (gouges, dishes, and/or imprints) to retain moisture for the vegetation of tailings. In addition core samples will be taken from two or more coal surface mine topsoil stockpiles of various ages and analyzed for soil fertility parameters. (SLRC)

8. Land Restoration Technical Development ***

Objective: To prepare statements of work and RFP's, review RFP's and USP's, evaluate proposals, monitor contracts, and provide support as needed for Land Restoration program. (SLRC)

9. Identification of Reclamation Problems in Metal and Nonmetal Mines in Alaska

Objective: To identify reclamation problems in metal and nonmetal mines in Alaska to serve as a base for pinpointing research needs. Results to date indicate that Alaskan lands will revegetate after mining. However, a deterrent to rapid revegetation is the weather. (SLRC)

10. Reclamation Equipment Application and Technology

Objective: To investigate, analyze, and monitor current reclamation technology and ongoing research in the surface mining industry. To identify existing problems and anticipate future developments, and formulate a coordinated program of research and development to improve mined-land reclamation. Emphasis will be placed on determining the feasibility of using draglines to recontour mined areas, assessing equipment instrumentation to control and optimize recontouring and reshaping of mined lands, determining the feasibility of using rubber-tired equipment to recontour mined areas, and identifying critical elements and subelements involved in reclamation and mining operations and the economic considerations involved in each area. (SPRC)

11. Computer-Supported Analysis of Surface Reclamation Systems

Objective: To use simulated models to evaluate new mine systems and reclamation equipment concepts proposed, developed, and demonstrated under the Minerals Environmental Technology program to determine the potential for improved reclamation technology of surface mining operations. To evaluate new and improved reclamation equipment and mining and/or environmetal systems for feasibility and cost effectiveness. Consideration will be given to updating surface mining simulation models by developing or acquiring new routines to simulate specialized equipment and to improving the efficiency and capability of current models. (SPRC)

12. Specialized Reclamation Equipment

Objective: To provide support for the Minerals Environmental Technology program in research and planning, contract research program development, pre paration of requests for proposals, evaluation of proposals, negotiating contracts, monitoring contract research, and disseminating information to interested parties. This program will provide personnel for proper evaluation and monitoring of authorized environmental research projects to insure adequat progress. (SPRC)

13. Electrokinetic Techniques for Sediment Pond Abandonment

Objective: To demonstrate through laboratory and field tests the feasibility of using direct current to clarify surface water and consolidate coal waste to facilitate reclamation of abandoned sediment ponds. (SPRC)

14. Iron Range Mined-Land Reclamation

Objective: To continue to gather information concerning the state of the art of iron-mined-land reclamation in cold climates and to establish research priorities for mined-land reclamation and postmining land use. Specific emphasis will be given to the effectiveness of natural versus planted vegetation growth on mined land, iron mining techniques to facilitate reclamation, postmining land use, and abandoned open pit reclamation. (TCRC)

15. Reprocessing Uranium Tailings To Facilitate Reclamation ***

Objective: To provide continued liaison and coordination between the Bureau of Mines research on reprocessing uranium tailings to facilitate reclamation and related projects at other agencies and to acquire relevant literature. (TCRC)

16. Weathering and Land Reclamation ***

Objective: To perform geochemical weathering studies on various soils and also on oxidized, roasted, and natural magnetite waste products to determine the environmental problems in land reclamation. (TCRC)

17. Impact of Mining on Soils

Objective: To assess the nature and extent of changes in soils disturbed by mining, and to make preliminary soils evaluations for developing strategies to minimize the adverse effects of mining. (TCRC)

18. Surface Mine Reclamation Technology

Objective: To provide planning and assistance on program development in Land Restoration when work requires preparing RFP's, evaluating RFP's and USP's, negotiating contracts, monitoring contract research, and transferring technology to industry. (TCRC)

Contract Projects

1. Land Use Planning Study for the Crow Indian Tribe in Southeastern Montana

Objective: To develop a prototype evaluation system for siting coal surface mines and to demonstrate this system on the coal reserve area of the Crow Indian Reservation in southeastern Montana. Mining, environmental, and land use factors are quantified in the system. (DRC/Harvard University)

2. A Systems Approach to Reclamation of Strip Mined Areas in North Dakota

Objective: To obtain and synthesize comprehensive information on the qualitative and quantitative aspects of a number of ecological variables operating in the process of revegetation and reclamation of surface-mined coal areas to acceptable biological productivity. (DRC/University of North Dakota)

3. Comprehensive Planning To Optimize Postmining Land Use Utilizing Water Harvesting

Objective: To demonstrate use of the water harvesting concept in a semiarid region as a means of obtaining an economic return to offset the cost of reclamation. This project includes the evaluation of a computer modeling effort in a previous study in order to maximize surface water runoff for a given site. The runoff water is captured in ponds and recycled through an irrigation system to create an agricultural final land use for part of the site. (DRC/University of Arizona)

4. Operator's Guide for Reclamation and Pollution Control on Small Sand and Gravel Mines

Objective: To develop a handbook for small sand and gravel operations that should help the operators plan for reclamation by incorporating a number of related factors including community relations, reclamation practices, land use considerations, and pollution control requirements. (DRC/Hittman Associates, Inc.) Note: Interstate Mining Compact Commission serves as technical advisor under a separate Bureau contract.

5. Enhancing Short- and Long-Range Availability of Nitrogen and Phosphorus on Topsoil-Deficient Mine Spoil

Objective: To conduct a series of experiments and technology transfer activities designed to improve short- and long-range availability of nitrogen and phosphorus in topsoil-deficient spoils, and to deliver research findings to mine operators, regulatory officers, extension coworkers, and other interested individuals through demonstration plots and written materials. This project will be targeted to steep slope spoils in Appalachia where topsoil is in short supply. (PRC/Virginia Polytechnic Institute and State University)

6. Establishment of Associative Nitrogen Fixing Grasses on Metal Mine Tailings

Objective: To select and test nitrogen-fixing grasses capable of growth on metal mine tailings in semiarid regions. (SLRC/Utah University)

7. Breeding of Improved Grasses for Mined-Land Reclamation

Objective: To make available to the Bureau of Mines the improved plant stock being developed by selective breeding for metal tolerance in a greenhouse and on a coal spoil by the Agricultural Research Crops Research Laboratory located in Logan, Utah. (SLRC/United States Department of Agriculture)

8. Toxic Overburden Material In Situ Detection System

Objective: To develop data and specifications for methods of locating surface and subsurface zones of deposits of toxic and/or unfavorable material in mining overburden. To review Federal and State regulations defining toxic

and/or unfavorable materials and segregation requirements. (SPRC/GAI Consultants, Inc.)

9. Remining as a Potential Tool To Accomplish Reclamation of Abandoned Tailings Ponds ***

Objective: To develop comprehensive mining and reclamation plans and methodology for remining mine and mill tailings pond waste materials and establish material content levels that would make recovery operations economically feasible. These plans shall be developed for actual sites.

10. Production, Engineering, Development, and Demonstration of the Draft Power Sensor

Objective: To develop and test an improved version of a draft power sensor to be attached to the dozers used in regrading spoil after mining. Previous research developed and tested a prototype sensor. The results indicated potential regrading cost savings and productivity increases. This project seeks to develop a rugged production version and expand the field testing. (SPRC/Southwest Research Institute)

11. Development of Guidelines for Mine Planning and Reclamation

Objective: To investigate and develop guidelines for mine planning and reclamation in order to identify and illustrate the relationship between the planning of mining activities and the relationship of the land. Consideration shall be given to the methods and approaches to be used in reclamation planning addressed in the early phase of mining, key features of mine planning that affect reclamation and the environment, identification of relative costs of reclamation practices, reclamation components that require treatment during the early stages of reclamation planning, and Federal and State regulatory requirements and how mined land reclamation is affected. These data shall be combined with existing reclamation data into a handbook. (SPRC/Intermountain Resources, Ltd.)

12. Specialized Land Reclamation Tools and the Transfer of New and Developing Technology to Active Mines

Objective: To introduce and successfully transfer to the surface coal mining industry the technology of specialized reclamation tools developed by the Bureau of Mines and the Pittsburgh and Midway Coal Mining Co. Initially, a 4-month demonstration of selected reclamation techniques was conducted. Four recontouring blades were successfully applied as a reclamation system designed to recontour area mine spoils. A second demonstration is being considered, and special dragline systems for recontouring will be field-tested. (SPRC/Russell and Sons Construction Co., Inc.)

13. Improved Interburden Handling Techniques at Multiseam Dragline Operations To Enhance Reclamation Practices

Objective: To evaluate and analyze the effects of different interburden handling techniques on ground water and the potential for revegetation, in accordance with requirements of the Surface Mining Control and Reclamation Act. A literature review shall be conducted on interburden handling concepts developed under previous Bureau of Mines research. Field studies at mine sites shall be performed with emphasis on the type of interburden handling used, the type of equipment used, and the problems or success with reclamation of surface vegetation and ground water resources directly related to interburden materials. The results of the study shall be used to identify problem areas and in preparing a list of recommendations for future research for improving interburden handling techniques at multiseam to recontour area mine spoils. A second demonstration is being considered, and special dragline operations to enhance reclamation practices. (SPRC/Mathematica, Inc.)

14. Topsoil Rock Removal

Objective: To develop and evaluate the engineering, economic, and legislative criteria that a topsoil rock removal system and/or equipment would be required to meet. Work shall include reviewing of all Federal and State reclamation regulations to determine what requirements must be met by mine operators concerning rock removal from the topsoil cover; determining the costs associated with topsoil rock removal; and identifying the decision criteria used by mining companies in their selection of surface topsoil rock removal equipment. Information from this study will be used to determine the feasibility of developing new or improving existing rock removal equipment for reclamation. (SPRC/Skelly and Loy)

15. Reclamation To Enhance Fish and Wildlife Habitat

Objective: To develop a coal mine operator's handbook to enhance fish and wildlife habitat in the Northern Great Plains Coal Province. The handbook will help operators select the proper plant species and/or water elements needed if they choose the wildlife option offered by Office of Surface Mining (OSM) regulations. (SPRC/Fish and Wildlife Service, Office of Biological Services)

16. Selective Placement of Toxic Overburden Material

Objective: To develop and demonstrate selective segregation concepts applicable to areas high in soluble salts and metallic mineral concentrations whereby toxic materials are identified, selectively handled, and segregated to minimize or eliminate contamination of the ground water system and the disturbed aquifer is reestablished through selective overburden placement. Project research work shall include baseline data collection and field demonstrations and evaluations. (SPRC/Montana State University)

17. Design and Development of Area Terrace Pit Mining Systems

Objective: To develop and evaluate conceptual terrace pit mining systems suitable for the recovery of single and multiple coal seams encountered in the Interior and Western Coal Provinces. Conceptual terrace pit systems shall be subjected to detailed engineering and economic feasibility and environmental benefit analyses, and detailed designs for the most promising systems shall be developed. Pertinent literature shall be reviewed to obtain and document engineering practices associated with terrace pit mining operations. Field surveys at terrace pit mining operations shall be conducted to document and evaluate current mining, reclamation, and equipment practices and to identify inherent operational problems associated with terrace pit mining operations. (SPRC/Dames and Moore)

18. Field Evaluation of Recontouring Systems ***

Objective: To develop guidelines for evaluating and selecting equipment used in reclaiming surface-mined land by studying a series of equipment under field conditions to determine their production and cost rates as well as operator acceptance in reclamation work.

19. Optimizing the Geometry of Recontoured Mined Land ***

Objective: To determine trade-offs in regrading mine spoil with respect to factors of slope length, slope angle, and aspect; the relationship of these factors to erosion, sedimentation, surface runoff, wind, and plant growth; and the optimum configuration for water conservation and vegetative establishment.

20. Modular Irrigation Equipment for Reclaimed Strip Mined Lands

Objective: To develop preliminary designs for a modular irrigation system(s) for revegetation of western surface-coal-mined-land. Each irrigation system shall be evaluated according to its technical and economic feasibility. A western mined-land characteristic literature search shall be conducted on soil characteristics, topography, climate and native species or crops to be grown. An investigation shall be conducted to evalute the potential advantages and disadvantages of various irrigation systems. Data from the study shall be used to develop preliminary irrigation system designs. (SPRC/Sherman and Sullivan)

21. Reclamation Planning for Enhanced Final Land Use in Sand and Gravel Operations ***

Objective: To conduct a detailed feasibility study comparing the company's existing reclamation plan with an artist's conceptual design for an active sand and gravel operation at Issaquah, Wash. The artist's design model was prepared under the Bureau's "Earthworks: Land Reclamation Sculpture" project.

22. Reclamation Planning for an Abandoned Western Surface Mined Coal Land ***

Objective: To plan, design and develop a reclamation plan and model using an artist's concept for an abandoned coal mine site near Hanna, Wyo. Implementation and construction of the earthwork will be accomplished through grants to Hanna from the Rural Abandoned Mines Program and National Endowment for the Arts.

23. Evaluation of an In Situ Neutron Activation Borehole Probe in Reclamation Studies

Objective: To test the applicability of in situ characterization of mine overburden by means of neutron activation techniques, and determine the minimum detectable limits for reclamation elements. The borehole probe shall be utilized to acquire prompt gamma and delayed gamma data at an agreed-to location. The data shall be analyzed, and a report shall be generated stating the minimum detectability of the elements of interest. Supportive technical recommendations shall then be made as to the applicability of the in situ borehole probe technique for over-burden characterization. (SPRC/Princeton Gamma-Tech., Inc.)

24. Reclamation of Tailings Basins Resulting From Copper-Nickel Milling Operations

Objective: To construct a test plot with tailings from the Minnamax copper-nickel pilot plant located near Babbitt, Minn. The plot shall be subdivided, treated with various amendments, and planted with various species. Growth response shall be evaluated, as well as resistance to wind and water erosion, ground water pollution, and rates of toxic metal concentrations in plant tissues. (TCRC/Barr Engineering Co.)

25. Impact of Surface Mining on Soil Compaction in the Midwestern United States

Objective: To measure the amount of change (premining to reclaimed) in bulk density (soil compaction), using four study sites representing different equipment systems currently being utilized on prime farmland. OSM regulations for soil compaction on prime farmlands have been suspended, and therefore results from this Bureau study might be useful for developing background data for a workable compaction regulation. (TCRC/Hittman Associates, Inc.)

26. Tug Valley Flood Study

Objective: To assess the relative effect of land use on the flooding problem of the Big Sandy River Basin in West Virginia, Kentucky, and Virginia with emphasis on the Tug Fork. To identify the magnitude and timing of peak flow hydrograph changes for a range of soil covers typically resulting from various land uses present in the Basin and to relate these to downstream flood inundations. Changes in runoff hydrographs are to be by land use and/or cover types. A secondary objective is to collect selected water quality data at certain mined areas. (WO/U.S. Geological Survey)

27. Methods for Reduction of Highwalls To Approximate Original Contour

Objective: To determine optimum equipment utilization procedures and their relative costs for eliminating the highwall and filling the final pit to approximate original contour at the conclusion of mining. Information from the study will be used to make recommendations on which new or present highwall reduction techniques seem most promising, based on existing and anticipated mining, environmental, and health and safety regulations for various ranges of geologic, topographic, and mining parameters. (DRC/Skelly and Loy)

28. Utilization of Nickel-Refining Byproducts on Agricultural Lands

Objective: To make plant growth and elemental uptake studies for spent laterite and ammonium phosphate byproducts additions to soil both in greenhouses and in field situations. Nutrient requirements and vegetative yields shall be determined for various application rates. (SLRC/Oregon State Univeristy)

29. Development of Improved Topsoil-Handling Techniques

Objective: To develop new techniques and equipment combinations that more effectively use topsoil for reclamation in accordance with State and Federal regulations. (SPRC/Skelly and Loy)

30. Development of Methods for Reclaiming Abandoned Tailings Ponds and Dams

Objective: To determine the state of the art and the problems involved in the removal of tailings ponds and dams in carrying out reclamation of abandoned mine sites, and to develop methods for reclaiming abandoned tailings ponds and dams. (SPRC/Harding-Lawson Associates)

31. Development of a Load-Haul-Dump Tree Clump Transplanter Attachment

Objective: To develop and fabricate an attachment for a front-end loader of 7 to 21 cubic yards capacity that will transplant clumps of trees for surface mine reclamation. The load-haul-dump system shall be field-tested and evaluated in an operating surface mine with an ongoing reclamation program. (SPRC/Colorado State University)

32. Analysis and Development of Selective Overburden Handling Mining Systems

Objective: To design and develop innovative systems using existing equipment for selectively excavating and placing the overburden in the optimum sequence to eliminate environmental problems and provide for postmining use as farmland. To develop functional specifications and concepts for new equipment capable of selectively excavating and depositing overburden and topsoil materials. (SPRC/Marston and Marston, Inc.)

33. Development of Systems for Leveling and Contouring Abandoned Spoil Banks

Objective: To investigate and evaluate the economic and engineering feasibility of innovative systems for leveling and recontouring abandoned spoil banks. To determine the applicability of present reclamation systems and large material-handling equipment for recontouring applications in abandoned coal lands. To develop innovative machine and/or system concepts to meet deficiencies related to recontouring abandoned coal lands. (SPRC/Golder Associates, Inc.)

34. Computer Simulation Model for Surface Mine Reclamation Planning

Objective: To extend the capabilities of the existing open pit material-handling simulator (OPMHS) to provide the logic necessary to simulate techniques for spoil leveling, highwall reduction, topsoil handling, and rock removal. The expansion of the OPMHS will provide the Bureau and the mining community with the capability to test research findings from the mining systems program in order to assess the feasibility of programs and the need for further research. (SPRC/Penn State University)

35. Development of Dragline Techniques for Reclaiming Spoil

Objective: To investigate, develop, and demonstrate special dragline reclamation techniques for reclaiming and recontouring spoil in applicable situations, such as filling modified-area mine final cuts, contouring head-of-hollow fill in mountaintop removal, relocating the large volumes of spoil atop the highwall when mining of dipping seams is completed, and moving spoil uphill to recontour conventional contour mining operations. (SPRC/ Mathtech, Inc.)

36. Development of Improved Topsoil Handling Techniques

Objective: To develop new techniques and equipment combinations that optimize and more effectively use the available topsoil so as to enable mining operations to meet State and Federal regulations. (SPRC/Skelly and Loy)

37. Soil as a Resource

Objective: A nationwide study is being conducted to develop a study program on the status of domestic soils. From the program should emerge a better understanding of the relationships between soil and other resources, such as coal, the development of which had a definite impact on the soil. (TCRC/National Academy of Science)

38. Technical Advice and Support in the Preparation of a Field Guide for Reclamation Planning and Pollution Control

Objective: To provide technical advice and support in the preparation of a field guide that will provide the small operator with information on reclamation and pollution control requirements and procedures. Sand and gravel is a high place-value commodity, and mining operations are generally located in

or near populated areas, whereby land-use and related conflicts often develop. (WO/Interstate Mining Compact Commission)

Surface Stability

This element's overall goal is to provide new and improved technology for predicting and controlling environmental problems associated with the short- and long-term physical integrity of land surface areas (including all structures located thereon) impacted by mining operations, and development of potential future land use applications for those areas. Specific goals of this element are to--

1. Develop and test on a regional basis, empirical and analytical techniques and models for subsidence prediction and control in longwall and room-and-pillar mining.

2. Develop comprehensive methodologies for analyzing the reactions, and mitigating the damages, of surface lands and structures to subsidence stresses.

3. Develop and demonstrate methods for stabilizing restored topsoil and overburden, spoil piles and fills, tailings ponds and embankments, and highwalls.

4. Determine mining reclamation, and mine closure practices that offer optimum postmining utilization and minimal environmental impact.

In-House Projects

1. Characterization of Subsidence Over Longwall Panels

Objective: To acquire and analyze subsidence data from western sites having representative mining methods and mine layouts, differences in topography, and a range of geologic characteristics. Monitoring networks will be established over active panels for correlation with existing data and available prediction techniques. (DRC)

2. Analysis of Subsidence Data From Solution Mining

Objective: To install and monitor a surface subsidence network over an active solution mine, and correlate these data with mining operations and geologic features in order to determine the feasibility of collapse prediction and control techniques. (DRC)

3. Analysis of Deformation and Stability of Surface Coal Mine Spoil

Objective: To investigate and describe the response to load of surface coal mine spoil materials, so that accurate predictions can be made of structural support characteristics, settlement, and mass stability for various mining and postmining configurations and geologic conditions. (DRC)

4. Information Center for Subsidence Data Technology ***

Objective: To establish a technical public information center that will provide a central source of available subsidence data and manuscripts, both published and unpublished, foreign and domestic, for use of industry, government, and academia in order to develop a national expertise in subsidence prediction and analysis for domestic mining conditions. (DRC)

5. Stress Research Applied to Mine Design and Subsidence Control

Objective: To investigate with field instrumentation the relationships between rock stress and mine design in order to determine subsidence potential and control measures for the emerging oil shale industry. The design process will be evaluated by full-scale field testing and correlated with predicted results. (DRC)

6. Laboratory Determination of Static Design Parameters of Rock

Objective: To determine under simulated field conditions the mechanical properties of fractured and unfractured rock, and the behavior of the medium under varying stress systems. The prototype rock modeling data will be used by engineers to evaluate the mine designs generated in the above oil shale project. (DRC)

7. Subsidence Technology Assessment

Objective: To develop research proposals that will produce economic and environmentally acceptable technology for solving or decreasing problems associated with subsidence and closure of underground mines. (DRC)

8. Development of Subsidence Prediction Techniques for Room-and-Pillar Mining

Objective: To collect available field data, install and monitor active surface panel networks, and develop empirical techniques for the prediction of ground movements over coal room and pillar extraction. These will be presented in a manual for use by both permit applicants and regulatory authorities relative to Public Law 95-87. (PRC)

9. Develop Procedures To Evaluate and Rank Candidate Sites for Subsidence Control Activity ***

Objective: To develop quantitative procedures to allow candidate sites for subsidence control to be comparatively evaluated, considering relative time of occurrence and size of area affected, severity and resulting damage, cost and potential effectiveness of control activity, and potential for improvements in control technology resulting from activity. (PRC)

10. Monitoring of Tristate Study

Objective: To evaluate existing hazards and known methods for public protection, including identification of potential areas for future damages resulting from lead-zinc mining, through technical administration and quality assurance of performance on contracts with State geologic surveys of Kansas, Oklahoma and Missouri. The Bureau will collate, edit, and synthesize the States' data for published final report. (RORC)

11. Instrumentation for Surveying Cavities Created by Borehole Mining

Objective: To develop and test a second-generation instrument package for surveying dimensions of cavities through 6-inch boreholes, incorporating both closed circuit television and still cameras, to be used for subsidence control activities. (TCRC)

12. Effects of Geologic Variation on Coal Mine Subsidence

Objective: To determine lithologic, spatial, and constitutive variables with attendant discontinuities which influence the development of the subsidence profile for use in phenomenological prediction techniques. (TCRC)

13. Subsidence Effects on Structures From Ground Surface Conditions

Objective: To collect and analyse data on subsidence damage to structures and subsidence profile information to determine the development of tension and compression zones, and develop a damage classification system that relates to cost repair normalized to assessed value. (TCRC)

Contract Projects

1. Stability Analysis of Valley Fill Construction ***

Objective: To identify relations between materials, design, construction, and performance of coal mine spoil fills, and determine the magnitude of expected problems related to stability, settlements, and seepage for various fills. Assessments shall be made of the available analytical methods for dealing with these problems, and parameters of model development, shall be recommended for spoil fill behavior prediction.

2. Environmental Effects of Slaking of Surface Mine Spoils

Objective: To determine effects on surface stability and erosion caused by deterioration of overburden materials exposed to weathering processes and water. A review of weathering research and testing precedes a field examination of four sites in selected mining districts. (DRC/D'Appolonia)

3. Study of the Coal Mine Stability Problems in the Eastern Coal Province

Objective: To quantitatively assess the slope instability problems associated with surface coal mining and recommend improved spoil techniques for

the variable materials and geologic and physiographic conditions of the region. (PRC/Law Engineering Testing Co.)

4. Development of a Conceptual Model for Room-and-Pillar Subsidence

Objective: To develop and validate a preliminary phenomenological predictive model, in equation form, that defines the various geomechanical, geological, and physiological parameters and their relationships, that affect the short-, intermediate-, and long-term stability of room-and-pillar coal mining operations and attendant subsurface and surface subsidence activity. (PRC/MRM Co.)

5. Surface Mine Closure Practices for Metal and Nonmetal Operations ***

Objective: To identify worldwide mine closure practice and effectiveness including methods of mining based upon the location and economics of open pit metal and nonmetal mines, identify gaps in closure technology, and determine feasible ideas for research, both short and long term, to return open pit mines to alternative productive use at the end of the mining cycle.

6. Influence of Rock Mass Discontinuities on Coal Mine Subsidence

Objective: To determine and define the effects of rock mass discontinuities, both regional and site-specific, on coal mine longwall subsidence. Using two-dimensional finite element analysis supported by comprehensive surface panel monitoring data and geomechanical laboratory and in-mine instrumentation data, the rock mass response to mining operations shall be modeled and the general applicability of the finite element technique shall be assessed as a subsidence prediction tool. (TCRC/Woodward-Clyde)

7. Survey of Ground Surface Conditions Affecting Structural Response to Subsidence

Objective: To determine how differences in near-surface materials affect the severity of subsidence-induced damage relative to the effects of mine geometry, extraction method, and thickness and/or depth of the coal seam(s). Also to define the relationships between ground surface conditions and behavior and observed damage effects, and recommend ground treatment and/or architectural measures for variable conditions. (TCRC/GAI Consultants)

8. Instrumentation for Remotely Detecting the Placement of Injected Backfill

Objective: To survey and analyze applicable methodologies and systems for monitoring backfill placement in blind stowing operations, and recommend the most feasible method for design or modification, (further) development, and field demonstration. (TCRC/Earthtech Research Corp.)

9. Case Study of the Sherwood Mine Closing

Objective: To monitor and determine the nature and extent of any physical changes in the mine and surrounding environment during "refilling" in

order to develop a methodology for the prediction and control of similar post-mining subsidence related to mine closure below water table. (TCRC/Michigan Tech)

10. Technical and Economic Feasibility of Using Cemented Backfill To Prevent Subsidence

Objective: To evaluate the feasibility of disposing of some or all of the coal-related wastes in active coal mines adjacent to powerplants by developing a mixture of those products (preparation plant rejects, powerplant fly ash, sulfate scrubber sludge, etc.) that can obtain sufficient strength for subsidence mitigation. (TCRC/Michael Baker Jr.)

11. Investigation of the Subsidence and Surface Collapse Features in Reclaimed Coal Mine Spoils

Objective: To determine the stability of regraded surface mine spoils from the Fort Union Formation and examine the resulting effect on ground water quality in order to help establish postmining land uses for the affected areas. (DRC/North Dakota Geological Survey)

12. Laboratory Experiments To Determine the Roof Behavior of Auger Mining With Aerostatic Support

Objective: To design, fabricate, and test a 1:20 scale model of auger mining with aerostatic support in order to determine the mechanism of roof behavior and the relationship between the support, overburden pressure, hole size and spacing, and physical properties of coal and rock. (TCRC/Engineers International)

13. Prediction of Ground Movement by Computer Simulation

Objective: To develop software and hardware with interactive graphics display of surface subsidence contours based on empirically developed influence functions for computing predicted subsidence profiles in longwall and room-and-pillar mining; to be validated against field data. (TCRC/Penn State University)

14. Demonstration of Coal Mine Haul Road Sediment Control Techniques

Objective: To demonstrate, in actual mining operations, the most effective of controlling the erosion that results from the construction of haul roads in the steeply sloping areas of Appalachia, and to collect quantitative data by remote instrumentation for evaluation of their effectiveness. (PRC/Commonwealth of Kentucky)

SPECIAL ENVIRONMENTAL PROBLEMS

Research performed by the Bureau of Mines in the Special Environmental Problems subprogram seeks to develop methods, equipment, and associated

technologies to abate environmental problems that may arise during a particular mining or processing operation. Specific goals of this subprogram are to--

1. Develop environmental control technology related to noise and ground vibrations.

2. Identify future environmental problems and hazards in the minerals industry and develop techniques for their control.

3. Establish analytical procedures and develop control technology for mineral particulates derived from mining and mineral-processing operations.

Noise and Vibration Control

This element of the subprogram focuses on the environmental problems associated with airblast and ground vibrations from blasting and ambient noise pollution from routine equipment usage.

In-House Projects

1. Application of Noise Abatement Techniques To Mine Environmental Noise Problems

Objective: To determine noise abatement techniques and promote their application to the solution of mine environmental noise problems. This will constitute the core project for the environmental noise program designed to correlate and integrate the contract research and demonstrate the techniques to the mining industry. (TCRC)

2. Control of Blast Noise and Vibration From Contour Mining of Coal in Appalachia

Objective: To determine airblast, ground vibration, and structure damage potential in contour strip mining and to develop design criteria which will minimize these environmental effects. (TCRC)

3. Analysis and Technical Review of Standards for Vibration and Noise from Blasting

Objective: To analyze proposed International Standards Organization and American Noise Standard Institute standards and provide technical support on criteria and measurement methods for airblast and ground vibrations. (TCRC)

4. Blast Design To Minimize Airblast and Ground Vibration

Objective: To develop design criteria based on current technology to minimize airblast and ground vibrations and still permit cost-effective blasting at surface mines. (TCRC)

5. Fatigue and Structural Damage of Residential Structures From Repeated Surface Mine Blasting

Objective: To determine criteria for fatigue and structural damage in residential homes due to ground vibrations from repeated blasting in surface coal mines, and to monitor and analyze damage to the test structure and a control home during low-level vibrations and initial aging, settlement, and weather effects. (TCRC)

6. Feasibility of the Development of a Precise Mine Blast Initiation System ***

Objective: To determine the feasibility of developing a blast initiation system that would allow precise, predetermined detonation of each individual blasting cap in a multidelay blast. (TCRC)

Contract Projects

1. Human Response to Blast Noise and Ground and Structure Vibrations

Objective: To determine the subjective response of humans to surface mine and quarry blasting by correlating human response with the amplitude, frequency, duration and damping characteristics of the air, ground, and structure vibrations. (TCRC/Bolt, Beranek, and Newman)

2. Technology for Noise Control in Surface Mines

Objective: To identify the environmental noise problems associated with mining operations, develop techniques for monitoring such noise, and identify and recommend technology for abatement of noise problems. (TCRC/ORI, Inc.)

3. Survey of Blast Damage to Water Supplies in Appalachia

Objective: To determine possible adverse environmental effects of blasting on ground water supplies in close proximity to contour coal mining operations in Appalachia. Ground vibrations associated with surface coal mine blasting are a major problem to homeowners near the mine sites. Not only can the vibrations cause damage to the residences, as shown in a number of Bureau studies, but a number of complaints exist in contour strip mining areas concerning loss of, or damage to, water wells caused by blasting. (TCRC/Philip R. Berger and Associates)

4. Noise From Surface Mining Equipment, Haulage Trucks ***

Objective: To develop cost-effective techniques for reducing the sound radiated from large haulage trucks without significantly reducing the efficiency of the trucks. Prototype techniques would be applied to trucks and demonstrate under actual operating conditions.

5. Standards on the Measurement of Human Acceptability of Blast Noise and Ground-Transmitted Vibration and Shock

Objective: To administer the national and international standards committees for which the Acoustical Society of America holds coordinating responsibility, specifically the technical areas of human and structural tolerance and measurement for noise and vibration. (TCRC/Acoustical Society of America)

Environmental Systems Analysis

This element of the subprogram is concerned with defining the environmental factors affecting mining of specific commodities and the development and demonstration of appropriate control technqiues. The results of research developed under present activities will provide lawmakers and industry with viable alternatives to the present environmentally disruptive techniques, as society demands greater improvements in the quality of our environment.

In-House Projects

1. Mine Waste Management Technology Development

Objective: To provide support for the Washington office in contract research program development, preparing requests for proposals, evaluating proposals, negotiating contracts, monitoring contract research, and disseminating the information to interested parties. (BCEL. DRC, PRC, SLRC, SPRC, TURC, TCRC)

2. Potential Environmental Problems Caused by Use of High-Vanadium Fuel ***

Objective: To prepare an evaluation of some coatings that might protect the metal surfaces of pollution abatement equipment from ash corrosion. Coatings with the best potential appear to be Al_2O_3 and Alonized stainless steels. (ALRC)

3. Environmental Constraints for Quarry Operators in an Urban Environment ***

Objective: To determine actual environmental problems in expanding as well as developing rock quarries along the Front Range in Colorado. More specifically, the project will look at environmental problems of noise, dust, erosion, and sedimentation, degradation of surface and ground water, revegetation, traffic, and aesthetics. The project will also look into reasons for public objections. (DRC)

4. Minerals Research: Research Management and Planning System (RMAPS)

Objective: To provide the Directorate, Minerals Research, and/or on request any other groups in cooperation with Minerals Research, information, assistance, and/or reports containing useful and timely data to assist them in their work. (DRC)

5. Systems Approach To Minimize Environmental Problems Associated With Major Mining Districts

Objective: To identify and evaluate the environmental problems, constraints, and causes common to major mining districts. The systems approach will allow the simultaneous evaluation of the interaction of a number of variables, such as environmental impact, economics, and mining method, to be conducted as the input parameters are varied. Short- and long-term plans will be devised to identify, develop, test, and demonstrate methods to ameliorate environmental problems without disruption of the mining or processing sequence. (SPRC)

6. Interaction With Industry on Research Programs of the Bureau and Industry-Specific Problems ***

Objective: To correlate with industry on research areas covering site-specific problems. Informal meetings will be held with industry to discuss the Bureau's research program and industry's areas of concern so that a strategy to solve the problems can be derived, based on specific problems and the Bureau's expertise. (SPRC)

7. Environmental Assessment of Ocean Mining Technology ***

Objective: To assess and evaluate the state of the art in ocean mining and related fields to assist Washington Headquarters in deciding on the nature and extent of the Bureau's role in deep ocean mining and processing technology. (TCRC)

8. Environmental Aspects of Mining in Minnesota and Wisconsin

Objective: To identify potential environmental problems related to uranium mining in northern Minnesota, and the environmental problems associated with tailings and other waste disposal methods applicable to the high sulfide wastes anticipated for the Crandon and Ladysmith areas of Wisconsin. (TCRC)

9. Analysis of Compliance Alternatives Related to Surface Mining Act

Objective: To determine and inventory Federal and State laws and regulations regarding permits to mine coal. Particular attention will be paid to the requirements of OSM in regard to surface mining and aspects of underground mining such as subsidence control and return of waste to abandoned underground workings. The high-cost tasks that must be performed to comply with the regulations will be identified. Where possible, Critical Path Method (CPM) Diagrams will be prepared with the idea of finding ways to streamline the overall permitting process and reduce costs but still maintain the process integrity. From the compilation of high-cost tasks, research to reduce the overall cost of compliance will be recommended. (TCRC)

10. Environmental Damage Assessment for In Situ Mining

Objective: To develop and test acoustic instrumentation and techniques to assess blast damage to pillars and other structures, and to characterize and evaluate potential environmental hazards resulting from mining operations. (TCRC)

Contract Projects

1. Environmental Monitoring of Boulder City Engineering Laboratory ***

Objective: To monitor the Boulder City Engineering Laboratory for environmental problem areas and test containment pond liner materials.

2. Preparation of an EIS for the Bureau of Mines Oil Shale Research Tract

Objective: To prepare an environmental import statement (EIS) for the Bureau Oil Shale Environmental Research Facility according to the National Environmental Policy Act process. Draft EIS to be completed by January 1981. (DRC/VTN, Colorado)

3. Environmental Instrumentation in Mining--Air and Water

Objective: To identify the full spectrum of environmental monitoring instrumentation to establish the monitoring options and potential capability in the mining industry. The 1977 Surface Mining Act and resulting regulatory requirements shall be used to identify specific monitoring goals. Manufacturers of monitoring instrumentation shall be requested to identify specific instruments, and their capabilities and limitations. A report shall be assembled listing the monitoring requirements and the instrumentation available to do the monitoring. The report shall include a discussion of the relative match between the state of the art in instrumentation and the requirements of the regulations. (SPRC/Hittman Associates)

4. Undercut and Fill System for Pitching Coal

Objective: To assess the technical and environmental practicality and economic feasibility of developing an undercut-and-fill mining system for steep by pitching by (50 dip or more) coal seams. The undercut mining system will consider several research developments. These include pressure filling with a buried pipe discharge under sufficient line pressure to maintain flow by "hydraulic lift," the utilization of cement foamers to create a cellular sand-cement mortar with better structural properties and reduced slurry viscosity, and the installation of preformed wire mesh panels to increase strength of roof panels. (SPRC/Foster-Miller)

5. Oil Shale Creep Testing at Elevated Temperatures

Objective: To develop a test program and conduct laboratory tests to determine the creep characteristic of oil shale at elevated temperatures and to incorporate the results with data and information developed under

separate contract to provide improved pillar design and subsidence prediction for commercial in situ retorting of oil shale. (TCRC/Terra Tek, Inc.)

6. Effect of In Situ Retorting on Oil Shale Pillars

Objective: To develop a test program for determining properties of oil shale that are important to in situ retorting of an industrial-sized operation (50,000 barrels per day, minimum). The results will provide information concerning the effects of large amounts of heat generated during the retorting process on strength of pillars (extent of weakening of support pillars, rubble as pillar support to prevent subsidence), extent of surface and subsurface damage or disruption, and Kerogen recovery from pillars. (TCRC/Colorado School of Mines)

7. Site Specific Investigation of Environmental Problems Associated With Surface Mining of Heavy Oil and Tar Sands

Objectives: To design a surface mining, oil separation, and waste disposal system, and quantify the environmental problems that must be over-come for a specific oil and/or tar sand deposit. A resource survey, site and mining method selection, and environmental analysis of selected concepts are being performed. (TCRC/Golder Associates)

8. Environmental-Technological Assessment for Peat Development on Block Island, R.I.

Objective: To conduct an environmental-technological assessment of using peat as a potential source of energy on Block Island, R.I., small island community which because of its separation from the mainland has the highest electrical energy costs in the United States. The environmental analysis shall include the quantification and qualification of the island's ecology. (Baseline data on air, water, land, flora, fauna, will be gathered and evaluated.) Using this information as a baseline control, each technological option for developing the island peat resources shall be evaluated for its potential impacts on the island environment. One of the more crucial areas of environmental investigation shall be the socioeconomic aspects of peat development on the island, and what the impacts might be for each of the technological options of development evaluated. (TCRC/ Planning Systems International)

9. Testing and Evaluating the Characteristics of Northern Peat Reclamation

Objective: To determine the proper mix ratio of subsoil, peat, and supplemental nutriment requirements to reclaim mined peat land into productive agricultural and/or forest land. Based on the test information, plots have been established for actual in-the-field testing for the determination of productivity. (TCRC/University of Minnesota)

10. Borehole Mining of Phosphate Ores

Objective: To determine the environmental, technical, and economic feasibility of mining phosphate ore with the Bureau of Mines borehole mining

system. The environmental factors to be considered include subsidence and effects upon groundwater. A survey of the land surface shall be made prior to the start of mining operations to establish a baseline for subsequent measurements of subsidence. Pre- and post-mining samples will also be taken to determine the groundwater quality. (TCRC/Flow Industries)

11. Environmental Program for the Bear Creek Hydraulic Borehole Mining Demonstration Test

Objective: To quantify potential environmental disturbances related to borehole uranium mining and formulate suggested guidelines for permitting and monitoring a commercial borehole mining operation. (TCRC/Rocky Mountain Energy)

Particulate Emissions Control

This element of the subprogram is concerned with the development of technology to resolve the environmental problems associated with mineral particles derived from mining and mineral-processing operations.

In-House Projects

1. Particulate Mineralogy

Objective: To develop new and improved methods of identification and measurement of mineral particulates. This will encompass measurement of chrysotile and fibrous amphiboles in crushed stone quarries, evaluation of fibrous minerals in public land areas, identification of fibrous particulates in mining and mineral-processing dusts, and characterization of fibrous minerals in consumer products. (AVRC)

2. Fugitive Dust Characterization and Quantification Related to Mining and Mineral-Processing Operations

Objective: To develop reliable procedures for assessing dust concentrations, to characterize dusts from mining and milling sources, and to develop and test control measures for fugitive dust from mine and milling sites. Fugitive dust control at mining and milling operations is a problem complicated by meteorological conditions, seasonal effects, local conditions, and dust characteristics. The interpretation of fugitive dust data and the demonstrated effectiveness of dust control measures will aid operators in complying with EPA and OSM standards and aid enforcement agencies by providing a statistically significant data base. (PRC)

3. Electromagnetic Drying of Fine Coal for Minimizing Environmental Degradation by Airborne Dust

Objective: To demonstrate a new, more efficient method of drying fine coal that will minimize airborne dust. This project will use microwave energy in the frequency range of 1 to 3 GHz to dry fine coal for selected sizes smaller than the plus- 1/4-inch fraction. (TCRC)

4. Control of Fugitive Emissions

Objective: To provide the mining industry with improved controls for fugitive emissions from mining and mineral processing operations. Open-source fugitive emission controls will be determined, and cost and effectiveness data will be obtained. (TCRC)

Contract Projects

1. Mineralogical and Size Distribution Studies of Amphibole Asbestos

Objective: To provide data on the characterization of amphibole asbestos materials. Size and aspect ratios of airborne amphiboles will be determined; chemical composition, fibril structure, and optical properties will also be included. (AVRC/University of Maryland)

2. Dust Control on Active Tailings Ponds ***

Objective: To determine the state-of-the-art-technology of dust control on active tailings ponds. Information on procedures of application, equipment used, additives used, type of tailing material, and area climate shall be collected. Potential environmental problems shall be delineated and recommendations shall be made.

3. Environmental Problems With Chemical Dust Suppressants ***

Objective: To determine any potential environmental or health effects associated with the chemical dust suppressants used by the surface mining industry for control of fugitive dust emissions, and to provide an estimate of the potential risk associated with the use of each of these chemicals so that they may be ranked on the basis of adverse effects.

4. Determine Effectiveness of Dust Controls for Unpaved Mine Roads ***

Objective: To determine the effectiveness (efficiency) of dust controls used on mine roads. The cost-effectiveness information will be used to update the dust control manual being prepared under a related contract. The control efficiency data will be used to calculate dust emission factors for unpaved roads. This information is required for permitting EIS preparation, and Best Available Control Technology (BACT) determinations. The results will enable mine operators to select and use road dust controls in compliance with Total Suspended Particulates (TSP) standards for air quality. The operator will benefit because he can select the most cost-effective method for compliance with BACT and Prevention of Significant Deterioration (PSD) standards.

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